DUNE HPgTPC gas from the safety point of view

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DUNE-ND Gas Special Meeting
2020 June 9

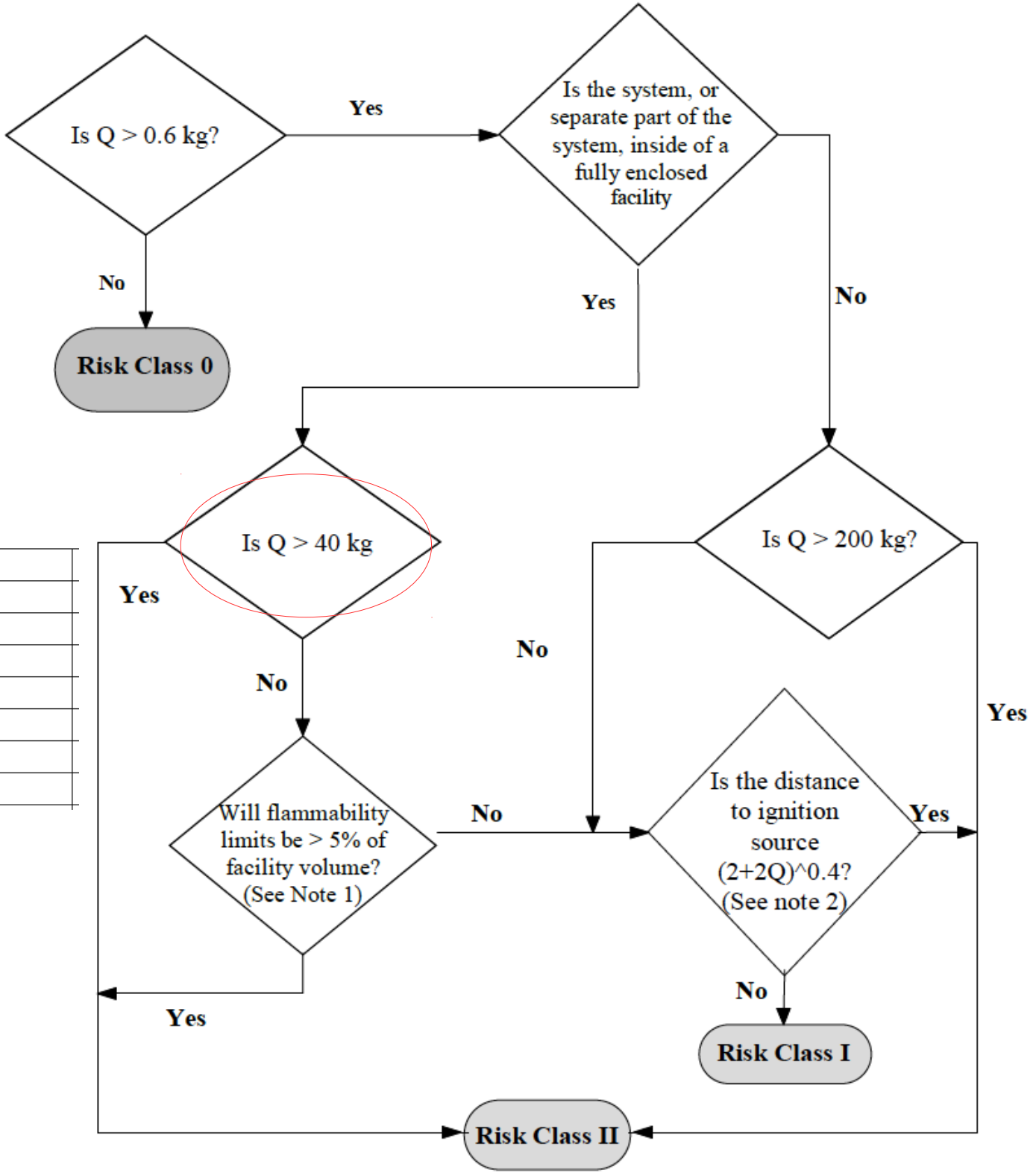
FESHM 6020.3

Hydrogen equivalence Q using the heat of combustion

Description	Mass (kg)
Hydrogen	0.6
Deuterium	1.2
Methane	1.5
Ethane	1.7
Propane	1.7
Isobutane	1.8
Dimethyl Ether	2.7

→ CH4 / H2 = 2.5

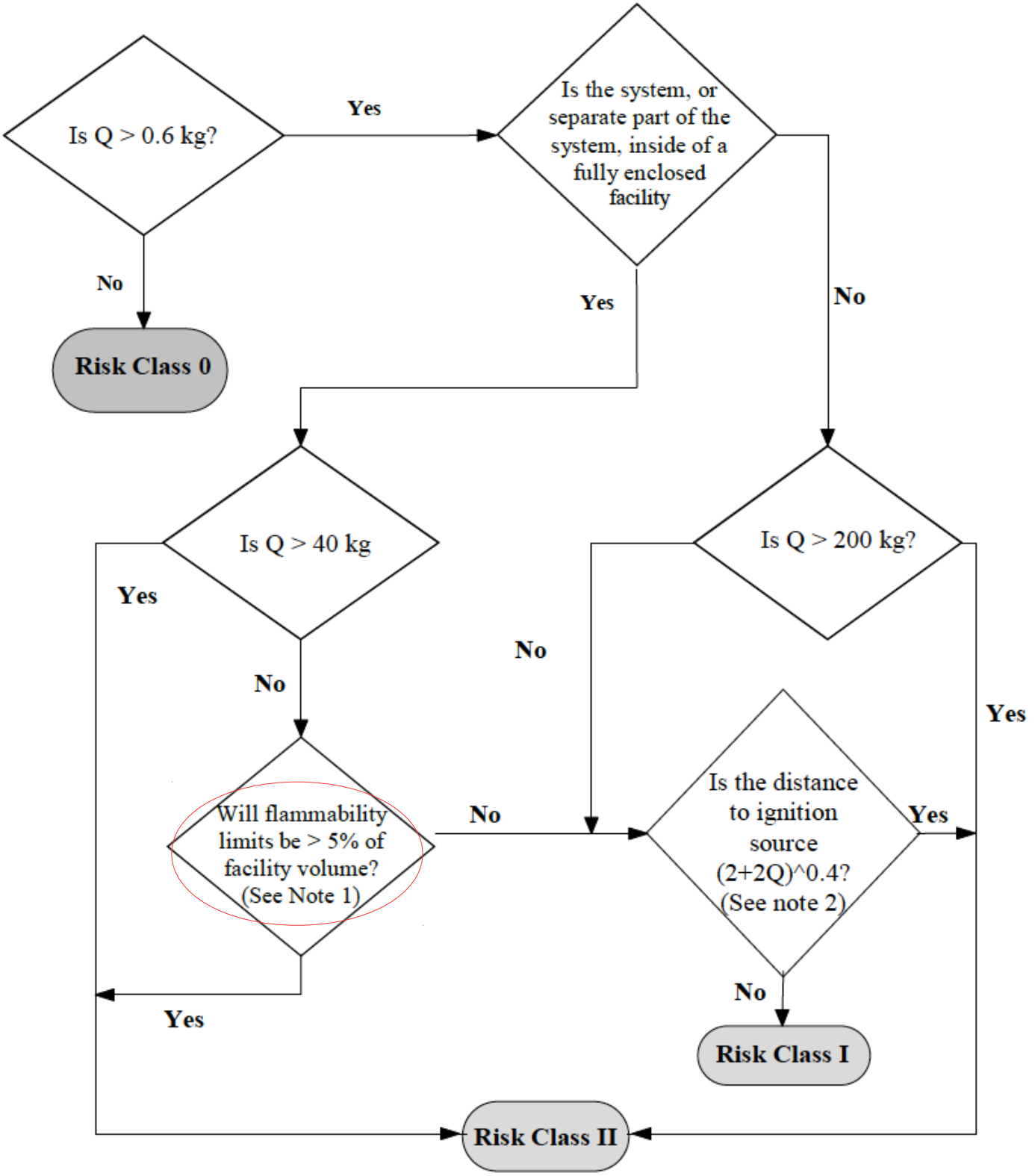
Alkane all similar



	specific heat of combustion J/kg (joules per kilogram)	full TPC volume m^3	pressure bar	density at 1bar 25C kg/m^3	density at 10 bar 25C (kg/m^3)	mass in full TPC at 10 bar 25C (kg)	FNAL Q threshold kg	allowed percentage
H2	1.42E+08	100	10	0.08	8.08E-01	81.27	40.00	49.22%
CH4	5.55E+07	100	10	0.65	6.59E+00	648.3	102.20	15.76%
C2H6	5.19E+07	100	10	1.22	1.32E+01	1222	109.27	8.94%
C3H8	5.00E+07	100	10	1.81	4.93E+02	1808	113.37	6.27%
D2	7.09E+07	100	10	0.16	1.62E+00	162.4	80.00	49.26%

→ 40kg H2 = 102 kg CH4

Assuming total gas volume 100 m^3, allowed percentage:
H2 : ~ 50%
CH4: 15%


Is Q > 0.6 kg?
Yes
Is the system, or separate part of the system, inside of a fully enclosed facility
No
Risk Class 0
Yes
No
Is Q > 40 kg
Is Q > 200 kg?
Yes
No
No
Yes
Will flammability limits be > 5% of facility volume? (See Note 1)
No
Is the distance to ignition source (2+2Q)^0.4? (See note 2)
Yes
Yes
No
Risk Class I
Risk Class II

Example 1

Two 81 SCF cylinders of a 50-50 mixture (by volume) of argon-ethane (Fermilab stock catalog number 1980-1095) will be used in a room whose volume is 9*15*20 ft^3 (2700 ft^3). This room, inside a larger building, contains no obvious fire hazards such as welding operations. The gas is to be supplied to drift chambers. First, to determine Q, it is recognized that only 40.5 SCF of a given cylinder is ethane. Thus, from Appendix 3 and Appendix 4;

$Q = 2*40.5\ ft^3\ *0.028(m^3/ft^3)*1.26(kg/m^3)*0.36(H_2\ equivalence\ factor)$

$Q = 1.03\ kg\ hydrogen\ equivalent\ inventory$

Thus by box 1 in the flowchart, we exceed the limit for Risk Class 0 and must go to box 2. Continuing to box 2, we find the answer to be yes but the answer to the question in box 3 is negative. Doing the calculation prescribed in box 4 we find that 5% of 2700 ft^3 is 135 ft^3. Dividing 81/135 finds a maximum concentration of 60 %, which exceeds the flammability upper limit. Thus, any concentration below this limit is reachable with the available inventory, since no inventory controls have been specified. Therefore the answer to this question is affirmative and the Risk Class is II. If only a single cylinder was needed, the Ø.5 kg hydrogen equivalence would have rendered a Risk Class 0 determination.

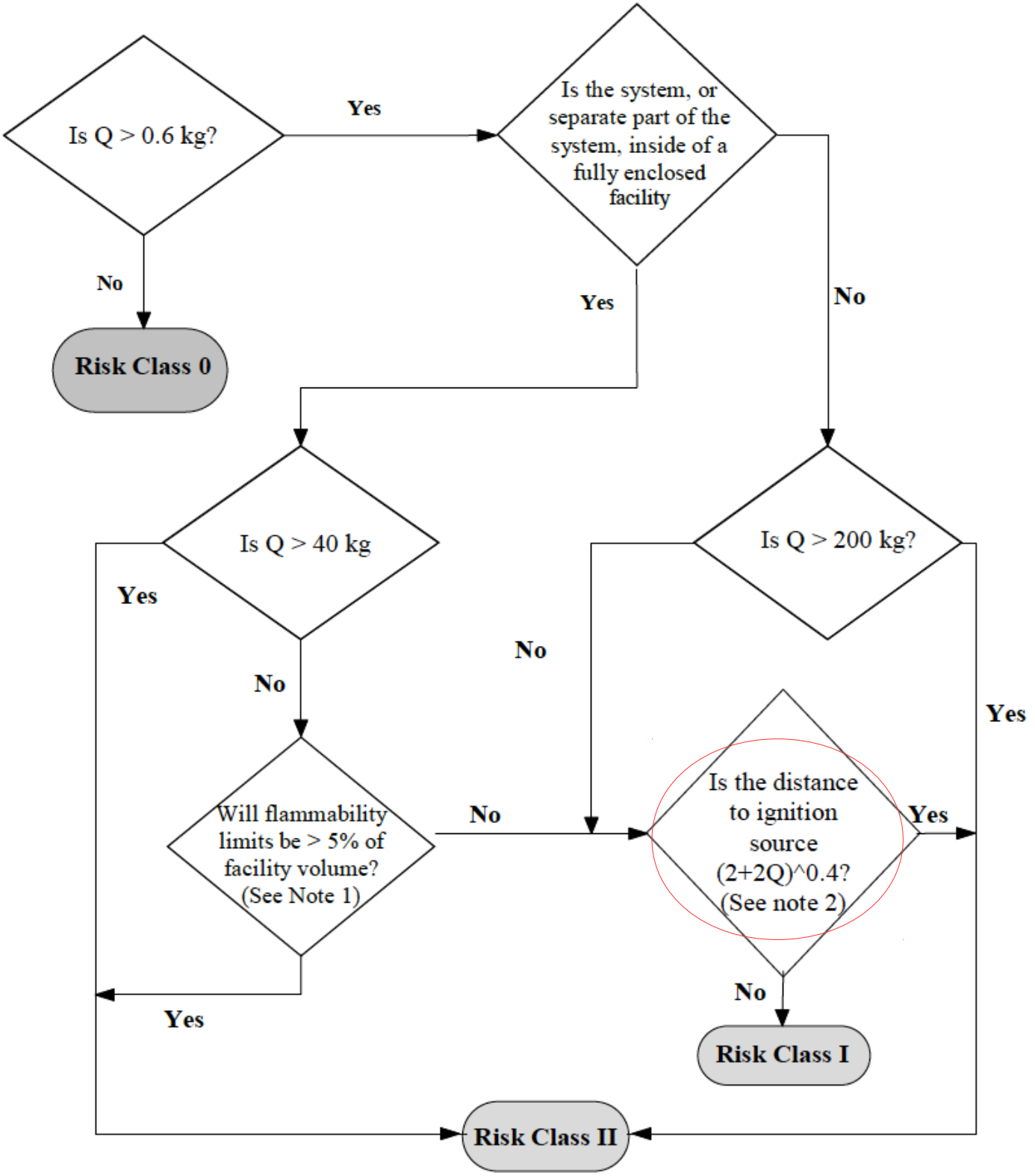
FESHM 6020.3 example

	flammability upper limit in % (from FESHM 6020.3 p17)	minimal facility volume (m^3) = gas volume at 1 bar/upper flam limit/5%
H2	75	1.31E+04
CH4	15	2.10E+04
C2H6	12.5	1.43E+04
C3H8	9.5	1.32E+04
D2	75	1.31E+04

Minimal facility volume at maximal allowed mass

Just match the current hall size 1.3E4 m^3

Very large due to the small upper limit


Is Q > 0.6 kg?
Yes
No
Risk Class 0
Is the system, or separate part of the system, inside of a fully enclosed facility
Yes
No
Is Q > 40 kg
Yes
No
Is Q > 200 kg?
No
Yes
Will flammability limits be > 5% of facility volume? (See Note 1)
No
Yes
Is the distance to ignition source (2+2Q)^0.4? (See note 2)
Yes
No
Risk Class I
Risk Class II

Example 2

This example is the same as that explored in example one except that these two cylinders are used to test a drift chamber in an open experimental hall 60*200*30 = 360,000 ft^3. The nearest ignition source is a temporary brazing operation at a distance of 40 ft (12.2 m). Following the flow chart, the same path is found until box 4 is reached. Five percent of this much larger room volume is 18,000 ft^3. Thus the maximum concentration in this volume would be 1.5 %, so that this question is answered negatively. At box number 6, we determine that objects or operations presenting an ignition hazard (the brazing operation) are more distant than the 2.0 m required by the formula based on the hydrogen equivalent quantity. Thus the Risk Class is I.

~ 1.75 m?

Q = 1.03 kg hydrogen equivalent inventory

(2+2Q)^0.4 = (2+2*1.03)^0.4 = 1.75

Discussions

1. According to FESHM 6020.3, 50% H2 and 15% CH4 (assumig 100m^3 volume) might be allowed
   - Is our interpretation correct regarding Q and minimal facility volume?

2. Distance to ignition still unclear to us.

3. Do we need to consider lower flammable limit (LFL)?
   - H2: 4%
   - CH4: 5%

4.0 PROGRAM DESCRIPTION FESHM 6020.3

Flammable gases may be diluted with inert gas to the point where the mixture is not flammable. This chapter does not apply to facilities using only non-flammable mixtures. The flammability of a mixture can be determined by referencing Bureau of Mines Bulletins 503 and 627 at http://www.osti.gov/bridge/servlets/purl/7328370-wx68Fy/ and http://www.osti.gov/bridge/servlets/purl/7355338/.

So Ar-5% CH4 is non-flammable and allowed?

4. Any other regulations we need to consider?

BACKUP

END